


I, Yoshihiro Ueda, of 4-17, Sasano-cho 2-chome, Hitachinaka-shi, Ibaraki-ken 312-0018, Japan, certify that the best of my knowledge and belief the following is a true translation made by me of the annexed document which is a copy of the specification of Japanese Patent Application Hei 08-136159 filed on May 30, 1996.

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Yoshihiro Ueda

[NAME OF DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION] CIRCUIT TAPE HAVING ADHESIVE  
FILM SEMICONDUCTOR DEVICE AND A METHOD FOR  
MANUFACTURING THE SAME

5 [WHAT IS CLAIMED IS]

[Claim 1]

A semiconductor device characterized in that  
a tape material having a circuit layer and a  
semiconductor device are electrically connected;

10 an external circuit for electric connection with a  
mounting substrate is provided on said circuit tape;  
and

a film material is used for adhesion between said  
circuit tape and semiconductor element in such a way  
15 that they are insulated from each other;

wherein said semiconductor device is further  
characterized in that the modulus of elasticity in the  
temperature range (200 to 250 degrees Celsius) under  
the reflow conditions for mounting said film material  
20 for adhesion is not less than 1 MPa.

[Claim 2]

A semiconductor device as claimed in Claim 1  
wherein said film material is composed in a three-  
layer structure having an adhesive layer on both sides  
25 of a supporter.

[Claim 3]

A semiconductor device as claimed in Claim 1 wherein said film material is composed in a structure having a porous supporter impregnated with adhesive.

5 [Claim 4]

A circuit tape comprising:

multiple metallic wires arranged on a substrate formed of a dielectric film, and

an adhesive layer that can be connected to a  
10 semiconductor element in an insulated state, wherein said adhesive layer is made of a film material, and

the modulus of elasticity in the temperature range (200 to 250 degrees Celsius) under reflow conditions  
15 for mounting is not less than 1 MPa, as a physical property of said adhesive layer.

[Claim 5]

A circuit tape as claimed in Claim 4 further characterized in that said dielectric insulating layer  
20 of the circuit tape equipped with said adhesive layer is made of polyimide based material and said metallic wiring conductor is made of copper.

[Claim 6]

A circuit tape as claimed in Claim 4 further  
25 characterized in that said metallic wiring conductor

of the circuit tape equipped with said adhesive layer is composed in a multilayer wiring structure.

[Claim 7]

5 A semiconductor device characterized in that the tape material with said circuit layer is electrically connected with said semiconductor by means of leads comprising circuits formed on said wire tape.

[Claim 8]

10 A semiconductor device as claimed in Claim 1 further characterized in that the tape material with said circuit layer is electrically connected with said semiconductor by wire bonding.

[Claim 9]

15 A semiconductor element manufacturing method comprising:

(1) a step of bonding an adhesive film on a semiconductor a tape having a circuit layer;

20 (2) a step of connecting a tape having a circuit layer to a semiconductor element through an adhesive film in an insulated state;

(3) a step of electric connection between a circuit layer formed on the tape and a pad on said semiconductor element;

25 (4) a step of encapsulating said electrically connected portion using an insulator; and

(5) a step of forming an external terminal for connection with a mounting substrate on said tape.

[Claim 10]

A semiconductor element manufacturing method  
5 comprising:

(1) a step of forming an adhesive film on a semiconductor;

(2) a step of connecting a tape having a circuit layer to a semiconductor element through an adhesive  
10 film in an insulated state;

(3) a step of electric connection between a circuit layer formed on the tape and a pad on said semiconductor element;

(4) a step of encapsulating said electrically  
15 connected portion using an insulator; and

(5) a step of forming an external terminal for connection with a mounting substrate on said tape.

[Claim 11]

A semiconductor element manufacturing method  
20 comprising:

(1) a step of registering the tape having circuit layer and a semiconductor element through an adhesive tape and bonding them together in an insulated state collectively;

25 (2) a step for electric connection between a

circuit layer formed on the tape and a pad on said semiconductor element;

(3) a step of encapsulating said electrically connected portion using an insulator; and

5 (4) a step of forming an external terminal for connection with a mounting substrate on said tape.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[FIELD OF THE INVENTION]

10 The present invention relates to a circuit tape, a semiconductor device and a method of manufacturing the same characterized by excellent electrical properties, mounting reliability, ease of assembling and capacities of meeting the requirements for high  
15 density mounting, multi-pin mounting and high-speed transmission.

[0002]

[PRIOR ARTS]

20 In recent years, there has been a growing demand for higher integration and higher density mounting of a semiconductor device to catch up with the advancing performances of electronic parts. Semiconductor elements have been improved to achieve higher integration and performances as exemplified in the LSI,  
25 VLSI and ULSI, and there has been an increase in the

size of an element, the number of pins, speeds and power consumption. To be compatible with such advances, the package structure of the semiconductor devices for multiple pins has changed from a structure where  
5 connecting terminals are provided on two sides of the semiconductor element to an advanced structure where connecting terminals are arranged on all four sides thereof. Further, in response to the increasing number of pins, a grid array structure has come to be put  
10 into practical use, wherein the connecting terminals are provided in a grid array over the entire mounting surface using a multilayer carrier substrate. This grid array structure includes a ball grid structure (BGA) having a reduced connection terminal length to  
15 allow high-speed signal transmission. The ball type structure of the connecting terminal increases the width of its conductor, and is also effective in decreasing inductance. Currently, to meet the requirements for faster signal transmission, organic  
20 materials having a relatively low dielectric constant are being investigated for use in a multilayer carrier substrate. However, organic materials generally have a greater thermal expansion coefficient than a semiconductor element, so thermal stress generated by  
25 the difference in thermal expansion raises a problem

of connection reliability. Recently, a structure without a carrier substrate has been proposed for use in BGA package. To put it more specifically, a new semiconductor element package structure has been disclosed (U.S. Pat. No. 5,148,265), wherein connection reliability is improved by using an elastomer material having a lower modulus of elasticity for reducing the thermal stress generated by the difference in thermal expansion between the semiconductor element and mounting substrate. The proposed package structure uses a circuit tape composed of a polyimide and the like, instead of a carrier substrate, for electrically connecting the semiconductor element and mounting substrate. Therefore, the electrical connections between the semiconductor element and the circuit tape are provided by a wire bonding method or a bonding connection with leads, and the circuit tape and the mounting substrate are electrically connected by soldering ball terminals. As the elastomer material of the prior art, a silicone material is generally used since this is a material having a low modulus of elasticity and a superior heat resistance. As a general method for forming a stress buffer layer using a silicone material, the steps of printing an uncured



liquid resin on the circuit tape using masks, and, Y  
subsequently, curing the printed resin, are generally  
used. However, this method has problems such as a  
difficulty in maintaining the flatness of the buffer  
5 layer obtained by printing, and the complexity of the  
time-consuming printing process. Accordingly, this  
method is not suitable for mass-Production process,  
and presents problems in assembling yield and mounting  
reliability because of the difficulty in ensuring  
10 flatness of the buffer layer.

[0003]

[PROBLEMS TO BE SOLVED BY THE INVENTION]

The object of the present invention is to disclose  
an art for obtaining a stress buffer layer  
15 Characterized by excellent flatness by using a film  
material as the elastomer material for reducing the  
thermal stress in a semiconductor device, and to  
provide a semiconductor device characterized by superb  
mass productivity.

20 [0004]

[MEANS FOR SOLVING THE PROBLEMS]

In order to realize the above object, the present  
invention provides a semiconductor device  
characterized in that a tape material having a circuit  
25 layer and a semiconductor device are electrically

connected;

an external circuit for electric connection with a mounting substrate is provided on said circuit tape; and a film material is used for adhesion between said circuit tape and semiconductor element in such a way  
5 that they are insulated from each other;

wherein the aforementioned semiconductor device is further characterized in that the modulus of elasticity in the temperature range (200 to 250  
10 degrees Celsius) under the reflow conditions for mounting the aforementioned film material for adhesion is not less than 1 MPa.

[0005]

The above film material for adhesion passes  
15 through the process for forming an external terminal, such as a solder ball add the like, for connection with the mounting substrate or a solder reflow Process for mounting the semiconductor element of the present invention onto a mounting substrate in the  
20 manufacturing process of the semiconductor devices. The reflow temperature is generally a high temperature in the range of 200 to 250 degrees Celsius. Therefore, moisture contained in the semiconductor device  
25 evaporates during the heat treatment, and the film material swells due to the vapor pressure of the

moisture. If the swelling exceeds a threshold value, a foaming phenomenon will occur with the result that defects, such as void formation, delamination and the like will occur. This requires the film material to have as low a moisture absorption rate as possible, and a high modulus of elasticity in the range of the reflow temperature. In the present invention, various film materials have been studied to find out that the adhesive material having a modulus of elasticity in the temperature range of a reflow process of at least 1 MPa has superb reflow characteristics. FIG. 1 shows examples of the dependency of the elastic modulus of the adhesive material on temperature.

[0006]

It has also been found that preferable result in anti-reflow characteristics can be obtained by using the material whose modulus of elasticity in the temperature range (200 to 250 degrees Celsius) of the mounting reflow conditions is maintained at not less than 1 MPa. The amount of swelling depends on the ratio of the vapor pressure to the modulus of elasticity: The higher the modulus of elasticity is, the less will be the amount of swelling. The foaming phenomenon will occur when the amount of swelling exceeds the break elongation, one of the mechanical

properties of the material. Furthermore, the modulus of elasticity correlates with the mechanical strength of the adhesive film material. Generally, the higher the modulus of elasticity is, the greater will be the break stress and break elongation. Therefore, the reflow characteristics can be improved in both the swelling amount and the mechanical characteristics by using a material having a high modulus of elasticity in the range of the reflow temperature. In the above case, the adhesive film material is formed of either a thermosetting resin or a thermoplastic resin.

[0007]

The adhesive layer is sometimes composed of either sticky adhesive agents or sticky-cohesive adhesive agents, in addition to the adhesive agents made of the above material. In order to maintain the modulus of elasticity at least at 1 MPa in the temperature range of the reflow process, the thermoplastic resin preferably has a glass transition temperature, i.e. a changing point of modulus of elasticity, which is higher than the temperature range (200 to 250 degrees Celsius) of the reflow process. The thermosetting resin is required to have a chemical or physical crosslinking structure to a certain degree at a temperature in the rubber region, which is higher than

the glass transition temperature. That is, the modulus of elasticity in the rubber region is generally proportional to the crosslinking density, and the crosslinking density must be increased in order to  
5 increase the modulus of elasticity. The film material is desirably composed of a resin having a low modulus of elasticity which is at the utmost 4000 MPa at room temperature, in order to operate as a stress buffer layer.

10 [0008]

As one of characteristics of a film material, the coefficient of moisture absorption at 85 degrees Celsius/85% RH for 168 hours is desirably, at the utmost, 3% in view of the reflow characteristics. As  
15 the film material, materials having a low modulus of elasticity, except for a silicone material, can be used. The structure of the film material is not restricted to a homogeneous structure composed of an adhesive agent component. It is also possible to use  
20 for instance, a three layer structure having adhesive layers at both surfaces of a supporter, respectively, or a structure in which the adhesive agent is impregnated into a porous supporter, As shapes of the film, various shapes manufactured by stamping, a mesh-  
25 like shape, and the like can be used. The mesh-like

shape is effective in improving the anti-reflow property at the time of moisture absorption, because the adhesion area can be decreased.

[0009]

5        In the case of a multilayer structure represented by a three layer structure, the supporter and the adhesive layer can be composed of a combination of at least two types of the aforementioned resins; thermosetting resin, thermoplastic resin, sticky  
10        adhesive agents, sticky-cohesive adhesive agents and the like. The adhesive layer is located at each of both surfaces. Each adhesive layer can be formed of a different kind of material from the other. A combination of different resins can be used; for  
15        example, a thermosetting resin having a high fluidity is used in order to flatten or eliminate the unevenness of the circuit layer of the circuit tape side, and a thermoplastic resin, which can be adhered in a short time at a high temperature is used to  
20        adhere the flat semiconductor on the opposite side.

[0010]

Fig. 2 is a schematic illustration showing a general semiconductor device fabrication process. A representative fabrication process can be divided into  
25        the following types: The first one (Fig. 2-a) is a

method for fabricating a semiconductor comprising (1) a step of applying an adhesive film to the tape having a circuit layer, (2) a step of adhering the tape having a circuit layer to the semiconductor element  
5 Through an adhesive film while maintaining an insulating condition therebetween, (3) a step of electrically connecting the circuit layer formed on the tape and the pad on the semiconductor element via connecting lead, (4) a step of encapsulating the  
10 aforementioned electrically connected portion with an insulating agent, and (5) a step of forming an external terminal on the tape for connection to the mounting substrate.

[0011]

15 The above method is effective in improving the processability, because the circuit tape and the film material can be handled in the manner of a long-reel process, as will be explained later.

A second method (Fig. 2-b) is a method for  
20 fabricating a semiconductor element comprising (1) a step of applying an adhesive film to the semiconductor element, (2) a step of adhering the tape having a circuit layer to the semiconductor element through the adhesive film while maintaining an insulating  
25 condition therebetween, (3) a step of electrically

connecting the circuit layer formed on the tape and the pad on the semiconductor element via connecting lead, (4) a step of encapsulating the electrically connected portion with an insulating agent and (5) a step of forming an external terminal on the tape for connection to the mounting substrate. The above method is effective in improving the production yield of the semiconductor element itself because this method allows a stress buffer layer to be formed on the semiconductor element in the phase of a wafer.

[0012]

A third method (Fig. 2-c) is a method of fabricating a semiconductor element comprising (1) a step of registering the tape having a circuit layer and a semiconductor element through an adhesive tape and bonding them together in an insulated state collectively, (2) a step of electrically connecting the circuit layer formed on the tape and the pad on the semiconductor element via connecting lead formed from wire, (3) a step of scaling the electrically connected portion with an insulating agent, and (4) a step of forming an external terminal on the tape for connection to the mounting substrate. This method is effective in shortening the manufacturing time, because the number of steps in the process can be



decreased.

[0013]

These methods essentially comprise the following steps: The adhesive film material of the present invention is provided between the tape material having the circuit layer and the semiconductor element by a certain method, and the tape material and the semiconductor element are bonded together simultaneously or sequentially under predetermined conditions (temperature, pressure and time). Subsequently, the circuit layer on the tape is electrically connected to the connecting pad of the semiconductor element. One of the connecting methods is to use a connecting lead previously formed on the circuit tape for connection with the semiconductor element by a circuit. In this case, either a single point bonding method, a gang bonding method or gang bonding method can be used.

[0014]

Another connection method is to use a wire bonding to connect between the two. Then the connection portion is encapsulated by an insulating material. And in the final stage, the external terminals, which are electrically connected with the mounting substrate, are formed on the circuit tape. When a solder ball is

generally used, ball formation method by plating is often used. When plating is adopted, gold, nickel, copper, solder, and the like can be used.

[0015]

5        In order to improve the mass productivity in the manufacturing process, the important process is the one where the adhesive film material is previously integrated with the circuit tape as shown in FIG. 2-a.

[0016]

10        The general method effective for mass production in this case is to transfer the tape with the pattern layer formed thereon through a long reel apparatus, to stamp out the adhesive film into a designated size, and to bond the adhesive film, as shown in FIG. 3. In  
15        this case, it is bonded to the circuit tape in the state of uncured stage A or uncured stage B. In the step of bonding with the semiconductor element using the circuit tape with adhesive film obtained in this manner, the resin is further cured until the stage C  
20        is reached. Alternatively, if stage C is reached in the step where the adhesive agent is integrated with the circuit stage, a new adhesive component is formed on the cured film portion in some cases.

[0017]

25        Coating method or film bonding method is generally

used as a method for formation. It is preferred that the adhesive component be not sticky at room temperature. But if it is sticky, a mold releasing paper or the like is used in some cases.

5 [0018]

Fig. 4 shows the configuration of the circuit tape with adhesive tape film. This adhesive tape can be bonded with the semiconductor element. In this case, a thermosetting resin is used for the adhesive layer on the circuit tape side, while a thermoplastic resin is used for the adhesive layer on the side adhered to the semiconductor element, whereby the circuit tape having the adhesive force shown in FIG. 4 can be provided easily.

15 [0019]

When the adhesive layer is composed of thermoplastic, sticky or cohesive material, the same conditions can be used for two steps of bonding to the circuit tape and to the semiconductor element. Unlike the case of thermosetting resin, manufacturing process superior in workability can be provided, without the need of controlling the in at the intermediate stage.

[0020]

The adhesive layer composed of a sticky or cohesive material is advantageous in that warpage of

the semiconductor element can be avoided because the material can be bonded at room temperature. When the adhesive film is initially integrated with the circuit tape, the semiconductor element can be easily  
5 registered at the time of bonding to the circuit tape. Accordingly, the jigs of the adhering apparatus can be simplified, and mass production can be promoted.

[0021]

In the semiconductor device according to the  
10 present invention, the unevenness of the pattern circuit on the circuit tape is eliminated by filling spaces with the adhesive layer of the film in some cases. In such cases, suitability of filling can be confirmed in the step of bonding the circuit tape and  
15 the semiconductor element. Therefore, an unsuitable adhesive layer can be eliminated before joining the circuit tape to the semiconductor element, thereby avoiding loss of a semiconductor element and improving production yield.

20 [0022]

Typical examples of a thermosetting resin and a thermoplastic resin for the adhesive component of the film materials are as follows: epoxy resin, polyimide resin, polyamide resin, cyan ate resin, isocyanate  
25 resin, fluorine-containing resin, silicon-containing

resin, urethane resin, acryl resin, styrene resin,  
maleimide resin, phenolic resin, unsaturated polyester  
resin, diallyl phthalate resin, cyanamide resin,  
polybutadiene resin, polyamideimide resin, polyether  
5 resin, polysulfone resin, polyester resin, polyolefine  
resin, polystyrene resin, polyvinyl chloride,  
transpolyisoprene resin, polyacetal resin,  
polycarbonate resin, polyphenylene ether resin,  
polyphenylene sulfide resin, polyacrylate resin,  
10 polyether imide resin, polyether sulfone resin,  
polyether ketone resin, liquid crystalline polyester  
resin, polyallylether nitrile resin,  
polybenzimidazole resin, various kinds of polymer  
blend, polymer alloys, and the like.

15 [0023]

These thermosetting resins and thermoplastic  
resins involve materials having an adhesiveness  
resulting from melting or softening of the material by  
heating. By contrast, the sticky or cohesive materials  
20 gain adhesiveness when subjected to pressure.

[0024]

Typical examples of sticky and cohesive materials  
include such rubber groups as silicone groups,  
butadiene groups and isoprene groups, acryl groups,  
25 polyvinyl ether groups and the like. The cohesive

material includes a room temperature curing type, a type cured by heat, ultraviolet ray irradiation, electron beam irradiation, and the like, a type cured by concurrent use of an accelerator, and the like. The  
5 room temperature curing type includes a moisture reactive type which reacts in the presence of moisture in the atmosphere, a photo-reactive type which contains a photo-initiator, and an anti-oxygen material which contains peroxide, and the like. The  
10 thermosetting resin generally includes a crosslinking agent, such as thiuram groups, phenol groups, isocyanate groups, and the like, and adhesive components are crosslinked three-dimensionally to form the adhesive layer at a designated temperature.

15 [0025]

The material of the type cured by ultraviolet ray irradiation, or electron beam irradiation, contains various photo-initiators. The material of the type cured by concurrent use of an accelerator includes a  
20 solution containing a reaction accelerator and a crosslinking agent, which are applied onto the surface of the sticky layer, wherein the adhesive layer is finally formed by mixing of these two agents due to contact pressure and reaction of these two agents  
25 sequentially. For the cohesive agent of the present

invention, a thermosetting resin is relatively preferable. The thermosetting resin makes it possible to provide a semiconductor device, which is superior in mass productivity and reliability by the method comprising the steps of registering the circuit tape and the semiconductor element at room to bond them together and elevating the temperature of a plurality of several sets to a designated degree simultaneously in a container such as a constant temperature bath for producing a curing reaction to ensure adhesive strength.

[0026]

The modulus of elasticity of the adhesive film material is preferably high in a high temperature region in view of the reflow characteristics, but as low as possible at room temperature. In this regard, the semiconductor element and the mounting substrate generally have different thermal expansion coefficients from each other, and a thermal stress is generated, when mounting is performed, at the external terminal, which is composed of a solder ball and the like. Then the reliability of the connection becomes remarkably important.

[0027]

If the modulus of elasticity of the adhesive film

existing between the semiconductor element and the mounting substrate is low, this portion becomes a stress buffer layer, and this is advantageous for connection reliability. The modulus of elasticity at room temperature is preferred not to exceed 4000 MPa. More preferably, the modulus of elasticity in the entire range of the heat cycling test (-55 to 150 degrees Celsius) does not exceed 2000 MPa. A silicone group material are often used as a material which has a high modulus of elasticity at a high temperature and a relatively low elastic modulus in a range of a low temperature including room temperature. A film material comprising a silicone group material is one of the extremely important materials in the present invention.

[0028]

However, film materials, other than the silicone group material having the above characteristics, Have the following advantages over the silicone group material: Since the silicone has a weak cohesive energy, silicone group compounds of cyclic low molecular weight are gradually decomposed thermally during a long-term heat treatment, such as during storage at a high temperature (for instance, 150 degrees Celsius or more), causing contamination of the



environment in some cases.

[0029]

The film material of the present invention is not only restricted to a homogeneous structure composed of the adhesive agent components alone. It can be composed in a three layer structure, such as a supporter having adhesive agent layers on both surfaces, or in a structure in which the adhesive agent is impregnated into a porous supporter. A film or porous material made of polyimide, epoxy, polyethylene terephthalate, cellulose, acetate, fluorine-containing polymer, and the like can be used as the supporter of a film material.

[0030]

As the shape of the film, various shapes obtainable by stamping out, a mesh-like shape and the like can be used. The mesh-like shape is effective in improving the anti-reflow property at the time of moisture absorption, because the adhesion area can be decreased. The three layer structure ensures that the thickness and type of the adhesive layer provided on both sides of the supporter can be controlled as desired and the fluidity of the adhesive layer at the time of adhesion can be readily controlled. Furthermore, the insulating layer is securely held by

the supporter located at the center.

[0031]

5 The value of vapor pressure of the adhesive material by moisture absorption at the time of reflow can be maintained at a low level by using the adhesive film material whose Saturated coefficient of moisture absorption at 85 degrees Celsius/85% RH. In this way, preferable reflow characteristics can be obtained.

[0032]

10 The tape having a circuit layer is generally composed of a flexible circuit substrate. That is, a polyimide group material is used as the insulating layer, and an epoxy group material, a polyimide group material, a phenolic group material, a polyamide group material and the like are used as the adhesive layer  
15 with the conductor. Generally, copper is used as the conductor. As the wiring circuit, the copper is sometimes coated with nickel, gold plating and the like. Some flexible circuit substrate uses the  
20 material with copper formed directly on the polyimide insulating layer, without using any adhesive layer with the conductor.

The tape having a circuit layer is sometimes composed in a multilayer wiring structure. In this  
25 case, a power supply layer and a ground layer and so

on in addition to the signal layer can be formed in the circuit tape, and so a semiconductor device which is superior in electric characteristics can be provided.

5           [0033]

Two typical arrangements of the pad terminal on the semiconductor element for electrically connection between the tape material having the circuit layer with the semiconductor element are as follows:

10           [0034]

The one is a peripheral pad arrangement as shown in FIG. 5. In this case, there are three different types of structure in the arrangement of the external terminals of the semiconductor device, as shown in FIG.

15   6. One is the type where the external terminals are located under the semiconductor element (Fan-in types, FIG. 6-1), another is the type where the external terminals are located outside the semiconductor element (Fan-out type, FIG. 6-2), and the rest is the  
20 type where the external terminals are located both under and outside the semiconductor element (Fan-in/out type, FIG. 6-3).

[0035]

Another example of the pad arrangement is the  
25 central arrangement shown in FIG. 7. FIG. 8 shows the

configuration of a semiconductor element in this case.

[0036]

The semiconductor element according to the present invention is defined as the one wherein IC, LSI and  
5 the like such as memories, logic devices, gate arrays, customs, power transistors and the like are formed on a wafer comprising semiconductor materials such as Si, GaAs and the like. It has terminals for connection with a lead, bump and the like.

10 [0037]

The present invention provides a semiconductor device characterized by excellent anti-reflow characteristics and connection reliability, wherein a tape having a circuit layer is used as an  
15 interconnecting between the semiconductor element and the mounting substrate, and the adhesive material used is a film material having a modulus of elasticity of at least 1 MPa in the reflow temperature region (200 to 250 degrees Celsius) as a high temperature region,  
20 with the circuit tape and the semiconductor element kept in an insulated state. Use of this film material provides a manufacturing method which is superior in mass productivity to the conventional printing methods.

[0038]

25 [DESCRIPTION OF THE PREFERRED EMBODIMENTS]

(Embodiment 1)

The epoxy group adhesive film (made by Hitachi Chemical Co., Ltd., AS3000, 50  $\mu\text{m}$  thick) was registered, placed and adhered between a semiconductor  
5 element and circuit tape at 170 degrees Celsius for one minute under a pressure of 50  $\text{kgf/cm}^2$ , and was then post-cured at 180 degrees Celsius for 60 minutes in a constant temperature bath. Subsequently, connecting leads on the circuit tape were electrically connected  
10 with the pads of the semiconductor element by single point bonding. The connecting portion was encapsulated with an epoxy encapsulant (made by Hitachi Chemical Co., Ltd., RC021C). Finally, the semiconductor device shown in FIG.6-1 was obtained by fixing the solder  
15 balls, which were connecting terminals with the mounting substrate, onto the circuit tape.

[0039]

After moisture was absorbed in a constant temperature bath at 85 degrees Celsius/85% RH for 168  
20 hours, the obtained semiconductor device was Placed in an infrared reflow apparatus having a maximum temperature of 245 degrees Celsius. Checks were made to see whether the adhesive layer exhibited defects such as delamination and voids resulting from foaming  
25 Further, the connection reliability between the lead

of the semiconductor device and the solder bump was checked. In this case, a woven glass-epoxy copper clad laminate FR-4 (made by Hitachi Chemical Co., Ltd., MCL-E-67) was used as the mounting substrate. The  
5 reliability was evaluated in 1,000 thermal test cycles (at  $-55 \leftrightarrow 150$  degrees Celsius).

(Embodiment 2)

A film material having a three layer structure was obtained by applying an adhesive agent (made by  
10 Hitachi Chemical Co., Ltd., DF335), composed of a die bonding film material, onto both surfaces of a polyimide film (made by Ube Kosan Co., Ltd., SGA, 50 microns thick) to a thickness of 50  $\mu\text{m}$ . The obtained film material was registered and adhered to the  
15 circuit tape at 170 degrees Celsius for five seconds under a pressure of 30  $\text{kgf/cm}^2$ . The unadhered adhesive layer exhibited a sufficient adhesive force to adhere to the semiconductor element.

[0040]

20 The circuit tape with the film material attached thereon was adhered to the semiconductor element at 200 degrees Celsius for one minute under a pressure of 30  $\text{kgf/cm}^2$ , and was then post-cured at 200 degrees Celsius for 60 minutes at a constant temperature bath.  
25 Subsequently, connecting leads on the circuit tape

were used for electrical connection with the pads of the semiconductor element by gang bonding. The connecting portion was encapsulated with an epoxy encapsulant (made by Hitachi Chemical Co., Ltd., RC021C). Finally, the semiconductor device shown in FIG. 6-2 was obtained by fixing the solder balls as terminals for connection with the mounting substrate onto the connecting tape.

[0041]

The reflow characteristics and connection reliability of the lead and the solder bump of the obtained semiconductor device were checked by the same method as the embodiment 1.

[0042]

(Embodiment 3)

A low elastic adhesive film composed of an epoxy resin and acrylic rubber (made by Hitachi Chemical Co., Ltd., trial product, 150 $\mu$ m thick) was registered, placed, and adhered between the semiconductor element and the circuit tape at 180 degrees Celsius for 30 seconds under a pressure of 100 kgf/cm<sup>2</sup>, and was then post-cured at 180°C Celsius for 60 minutes in a constant temperature bath. Subsequently, connecting leads on the circuit tape were used for electrical connection with the pads of the semiconductor element

by wire bonding. The connecting portion was encapsulated with a silicone encapsulant (made by Toshiba Silicone Co., Ltd., TSJ 3150). Finally, the semiconductor device shown in FIG. 6-3 was obtained by  
5 fixing the solder balls as terminals for connection with the mounting substrate, onto the circuit tape.

[0043]

The reflow characteristics and connection reliability of the 30 lead. and the solder bump of the  
10 obtained semiconductor device were checked by the same method as the embodiment 1.

[0044]

(Embodiment 4)

A film material having a three layer structure was  
15 obtained by adhering a less elastic adhesive film composed of epoxy resin and acrylic rubber (made by Hitachi Chemical Co., Ltd., trial product, 50  $\mu$ m thick) to both surfaces of a woven glass-epoxy resin laminate (obtained by eliminating a copper cladding by  
20 etching from both surfaces of MCL-E-679 made by Hitachi Chemical Co., Ltd.).

[0045]

This film material was registered, placed, and adhered between the semiconductor element and the  
25 circuit tape at 200 degrees Celsius for 20 seconds



under a pressure of 80 kgf/cm<sup>2</sup>, and was then post-cured at 180 degrees Celsius for 60 minutes in a constant temperature bath. Subsequently, connecting leads on the circuit tape were used for electrical connection with the pads of the semiconductor element by single point bonding. The connecting portion was encapsulated with a silicone encapsulant (made by Toshiba Silicone Co., Ltd., TSJ 3153). Finally, the semiconductor device shown in FIG. 8 was obtained by fixing the solder balls as terminals for connection with the mounting substrate.

[0046]

The reflow characteristics and connection reliability of the lead and the solder bump of the obtained semiconductor device were checked by the same method as the embodiment 1.

[0047]

(Embodiment 5)

A LOC film (made by Hitachi Chemical Co., Ltd., HM122U, 100 microns thick) having a three layer structure was registered and adhered to the circuit tape at 300 degrees Celsius for 2 seconds under a pressure of 150 kgf/cm<sup>2</sup>. In the process of adhesion, the film was stamped out into a designated shape using the long scale apparatus shown in FIG. 2, and the

stamped film was adhered to the circuit tape continuously. Because the adhesive layer of the film was made of a thermoplastic resin, the unadhered portion of the adhesive layer has a sufficient force  
5 for adhesion to the semiconductor element.

[0048]

The circuit tape with the film material was adhered to the semiconductor element at 300 degrees Celsius for 10 seconds under a pressure of 100 kgf/cm<sup>2</sup>.  
10 Subsequently, connecting leads on the circuit tape were used for electrical connection with the pads of the conductor element by single point bonding. The connecting portion was encapsulated with an epoxy encapsulant (made by Hokuriku Toryo Co., Ltd. Chip  
15 Coat 8107). Finally, the semiconductor device shown in FIG. 6-1 was obtained by fixing the solder balls as terminals for connection with the mounting substrate onto the circuit tape.

[0049]

20 The reflow characteristics and connection reliability of the lead and the solder bump of the obtained semiconductor device were checked by the same method as the embodiment 1.

[0050]

25 (Embodiment 6)

A thermoplastic polyimide film (made by Mitsui Toatsu Chemicals, Inc., Regulus PI-UAY, 100 microns thick) was registered and adhered to the semiconductor element at 250 degrees Celsius for 2 seconds with a  
5 pressure of 30 kgf/cm<sup>2</sup>. The film had a sufficient adhesive force to adhere to the circuit tape because it was made of thermoplastic resin.

[0051]

The semiconductor element with the film material  
10 was adhered to the circuit tape at 250 degrees Celsius for 10 minutes under a pressure of 20 kgt/cm<sup>2</sup>. Subsequently, connecting leads on the circuit tape were used for electrical connection with the pad of the semiconductor element by wire bonding. The  
15 connecting portion was encapsulated with an epoxy encapsulant (made by Hokuriku Toryo Co., Ltd. Chip Coat 8107). Finally, the semiconductor device shown in FIG. 6-2 was obtained by fixing the solder balls as terminals for connection with the mounting substrate  
20 onto the circuit tape.

[0052]

The reflow characteristics and connection reliability of the lead and the solder bump of the obtained semiconductor device were checked by the same  
25 method as the embodiment 1.

[0053]

(Embodiment 7)

A film material composed of a three layer structure having two different types of adhesive layers was obtained by applying a fluorine-containing polyimide (a reactant of hexafluorobisphenol AF and bis(4-aminophenoxyphenyl)hexafluoropropane, glass transition temperature at 260 degrees Celsius) onto one surface of a polyimide film (made by Ube Kosan Co., Ltd., SGA, 50 microns thick) to a thickness of 50 microns and a polyetheretherketone (a reactant of dihydroxy-naphthalene and difluorobenzophenone, glass transition temperature at 154°C) onto the other surface of the polyimide film to a thickness of 50 microns.

[0054]

The obtained film material was registered and adhered to the circuit tape using the adhesive layer having a lower glass transition temperature at 200 degrees Celsius for one minute at a pressure of 30 kgf/cm<sup>2</sup>. Because the adhesive layer of the film was composed of a thermoplastic resin, the adhesive layer had a sufficient adhering force to adhere to the semiconductor element. The circuit tape with the film material was adhered to the semiconductor element at 300 degrees Celsius for ten seconds under a pressure

of 80 kgf/cm<sup>2</sup>. Subsequently, connecting leads on the circuit tape were used for electrical connection with the pads of the semiconductor element by gang bonding. The connecting portion was encapsulated by an epoxy  
5 encapsulant (made by Hokuriku Toryo Co., Ltd., Chip Coat 8107). Finally, the semiconductor device shown in FIG. 6-3 was obtained by fixing the solder balls as terminals for connection with the mounting substrate onto the circuit tape.

10 [0055]

The reflow characteristics and connection reliability of the lead and the solder bump of the obtained semiconductor device were checked by the same method as the embodiment 1.

15 [0056]

(Embodiment 8)

A silicone adhesive agent (made by Shinetsu Chemical Co., Ltd., KE1820) was applied onto one surface of a silicone film (made by Toray Dow Corning  
20 Silicone Co., Ltd., JCR6126, 150 microns thick, press-fabricated) to a thickness of 20 microns. Then the silicone was registered and adhered to the circuit tape at 150 degrees Celsius for one minute under a pressure of 30 kgf/cm<sup>2</sup>. Further, in order to adhere  
25 the semiconductor element, the silicone adhesive agent

(made by Shinetsu chemical Co., Ltd. KE1820) was applied onto the other surface of the silicone film to a thickness of 20 microns, whereby the circuit tape with film material attached thereto was adhered to the semiconductor element at 200 degrees Celsius for 30 seconds under a pressure of 20 kgf/cm<sup>2</sup>. Subsequently, connecting leads on the circuit tape were used for electrical connection with the pads of the semiconductor element by gang bopping. The connecting portion was encapsulated with a silicone encapsulant (made by Toray Dow Coning Silicone Co., Ltd., DA 6501). Finally, the semiconductor device shown in FIG. 8 was obtained by fixing the solder balls terminals for connection with the mounting substrate onto the circuit tape.

[0057]

The reflow characteristics and connection reliability of the leads and solder bump of the obtained semiconductor element were checked by the same method as the embodiment 1.

[0058]

(Embodiment 9)

Porous polytetrafluoroethylene (made by Japan Goretex Inc., 190 microns thick) with BT resin (bismaleimide-triazine resin) applied on both of the

surfaces thereof was registered and adhered to the circuit tape at 150°C for one minute under a pressure of 30 kgf/cm<sup>2</sup>. Because the adhesive layer of the film was in a B stage condition (half-cured condition) of the thermosetting resin, the adhesive layer had a sufficient adhering force to adhere to semiconductor element.

[0059]

The adhesion of the circuit tape with the film material was conducted at 200 degrees Celsius for two minutes under a pressure of 70 kgf/cm<sup>2</sup>. Subsequently, the connecting leads on the circuit tape were used for electrical connection with the pads of the semiconductor element by gang bonding. The connected portion was encapsulated with an epoxy encapsulant (made by Hitachi Chemical Co., Ltd, R021C). Finally, the semiconductor device shown in FIG. 6-1 was obtained by fixing the solder balls as terminals for connection with the mounting substrate onto the circuit tape.

[0060]

The reflow characteristics and connection reliability of the lead and the solder bump of the obtained semiconductor device were checked by the same method as the embodiment 1.

(Embodiment 10)

A sticky tape having a three layer structure (made by Teraoka Seisakusyo, Ltd., Tape No. 760, 145 microns thick, silicone adhesive agent was applied onto both surfaces of Kapton film) was registered and adhered to the circuit tape at room temperature for 5 seconds under a pressure of 50 kgf/cm<sup>2</sup>. In the process of adhesion, the film was stamped out into a designated shape, using the long scale apparatus shown in FIG. 3, and the stamped film was adhered to the circuit tape continuously. Because the adhesive layer of the film was made of a sticky resin, the unadhered portion of the adhesive layer still had a sufficient adhering force to adhere to the semiconductor element.

[0062]

The circuit tape with the film material was adhered to the semiconductor element at room temperature for 10 seconds under a pressure of 5 kgf/cm<sup>2</sup>. Subsequently, connecting leads on the circuit tape were used for electrical connection with the pad of the semiconductor element by single point bonding. The connecting portion was encapsulated with a silicone encapsulant (made by Toshiba Silicone Co., Ltd. TSJ 3150). Finally, the semiconductor device shown in FIG. 6-2 was obtained by fixing the solder



balls as the terminals for connection with the mounting substrate onto the circuit tape.

[0063]

5 The reflow characteristics and connection reliability of the leads and the solder bump of the obtained semiconductor element were checked by the same method as the embodiment 1.

[0064]

(Embodiment 11)

10 A cohesive tape having a three layer structure (150 microns thick, butadiene adhesive agent was applied onto both surfaces of unwoven aramid non-woven cloth (100 microns thick)) was registered and adhered between semiconductor and circuit tape at the room  
15 temperature for 5 seconds under a pressure of 50 kgf/cm<sup>2</sup>. Under the above condition, some correction of the registration was possible because it was sticky. Then the adhesive layer of the film was cured at 180  
20 degrees Celsius for 60 minutes in a constant temperature bath to form an adhesive state having a three dimensional crosslinking structure, because the additive layer was made of a cohesive resin.

[0065]

25 Subsequently, connecting leads on the circuit tape were used for electrical connection with the pads of

the semiconductor element by single point bonding. The connection portion was encapsulated with a silicone encapsulant (made by Toshiba Silicone Co., Ltd., TSJ 3150). Finally, the semiconductor device shown in FIG. 6-3 was obtained by fixing the solder balls as the terminals for connection with mounting substrate onto the circuit tape.

[0066]

The reflow characteristics and connection reliability of the leads, and the solder bump of the obtained semiconductor element were checked by the same method as the embodiment 1.

[0067]

(Embodiment 12)

A polyamic acid was prepared by reacting an equivalent of benzophenone tetracarboxylic acid dianhydride (made by Wako Pure Chemicals) and bis(4(2-aminophenoxyphenyl)ether) (synthetic chemical) at 50 degrees Celsius in dimethylacetamide. Then the reactant was heated at 250 degrees Celsius to obtain polyimide. Then 100 grams of the obtained polyimide was mixed with 19.5 grams of 4,4'-glycidyl-3,3', 5-5'-tetramethyl biphenylether (made by Yuka Shell), 10.6 grams of phenol novella (made by Meiwa Kasei) and 0.2 grams of triphenylphosphate (made by Wako Pure

Chemicals) as a catalyst in dimethylacetamide to obtain 20% by weight of a varnish containing a non-volatile component. A 100-micron thick film was prepared with this varnish.

5 [0068]

The prepared film was registered and adhered to the circuit tape at 170 degrees Celsius for ten seconds under a pressure of 30 kgf/cm<sup>2</sup>. Under this condition, the unadhered portion of the adhesive layer had a sufficient adhering force to adhere to a semiconductor element. The circuit tape with the film material was adhered to the semiconductor element at 200 degrees Celsius for one minute under a pressure of 30 kgf/cm<sup>2</sup>. Subsequently, a post-curing was performed at 200 degrees Celsius for 60 minutes in a constant temperature bath. Then the connecting leads on the circuit tape were used for electrical connection with the pads of the semiconductor element by gang bonding. The connection portion was encapsulated with an epoxy encapsulant (made by Hitachi Chemical Co., Ltd., RC021C). Finally, the semiconductor device shown in FIG. 6-2 was obtained by fixing the solder balls as the terminals for connection with the mounting substrate onto the circuit tape.

25 [0069]

The reflow characteristics and connection reliability of the leads and the solder bump of the obtained semiconductor device were checked by the same method as the embodiment 1.

5 [0070]

(Embodiment 13)

A film having a three layer structure was prepared by applying the vanish obtained in the embodiment 12 onto the one surface of polyimide film (made by Ube  
10 Kosan Co., Ltd., SGA, 50 microns thick) to a thickness of 20  $\mu\text{m}$  (thermosetting resin component), and the fluorine-containing polyimide, i.e., the vanish prepared in the embodiment 7, (the reactant of hexafluorobisphenol AF and bis(4-aminophenoxyphenyl)  
15 hexafluoropropane, at a glass transition temperature of 260 degrees Celsius) was applied onto the other surface of the polyimide film to a thickness of 10 microns (thermoplastic resin component). The film was registered and adhered to the circuit tape on the side  
20 of the thermosetting resin component.

[0071]

The adhesion was carried out at 170 degrees Celsius for 10 seconds under a pressure of 30  $\text{kgf/cm}^2$ . Then, post-curing was performed at 200 degrees Celsius  
25 for 60 minutes in a constant temperature bath.

Subsequently, the semiconductor element was adhered to the surface where the thermoplastic resin component was applied. The adhesion was carried out at 350 degrees Celsius or 2 seconds under a pressure of 80 kgf/cm<sup>2</sup>. Then connecting leads on the circuit tape were used for electrical connection with the pads of the semiconductor element by gang bonding. The connecting portion was encapsulated with an epoxy encapsulant (made by Hokuriku Toryo, Chip Coat 8107). Finally, the semiconductor device shown in FIG. 6-2 was obtained by fixing the solder balls as the terminals for connection with the mounting substrate onto the circuit tape.

[0072]

The reflow characteristics and connection reliability and the lead and the solder bump of the obtained semiconductor device were checked by the same method as the embodiment 1.

[0073]

(COMPARATIVE EXAMPLE 1)

A 150-micron thick elastomer of 150 was formed by registering silicone resin (made by Toray Dow Corning Silicone Co., Ltd., JCR 6126) with the circuit tape and by printing using metal masks. After the formation, printing by curing reaction was performed at 150

degrees Celsius for 60 minutes in a constant temperature bath. Then, the flatness of the elastomer was measured by a laser film thickness measuring apparatus. A silicone adhesive agent (made by Shinetsu Chemical Co., Ltd., KE1820) was applied onto the surface of the elastomer to a thickness of 20 microns as an adhesive layer for causing the semiconductor element to adhere to the circuit tape having the elastomer, and the circuit was registered and adhered to the semiconductor element.

[0074]

The adhesion was carried out at 150 degrees Celsius for one minute under a pressure of 30 kgf/cm<sup>2</sup>. Then connecting leads on the circuit tape were used for electrical connection with the pads of the semiconductor element by gang bonding. The connecting portion was encapsulated with a silicone encapsulant (made by Toshiba Silicone, TSJ3150). Finally, the semiconductor device shown in FIG. 6-1 was obtained by fixing the solder bans as the terminals for connection with the mounting substrate onto the circuit tape.

[0075]

The reflow characteristics and connection reliability of the lead and the solder bump of the obtained semiconductor device were checked by the same

method as the embodiment 1.

[0076]

(COMPARATIVE EXAMPLE 2)

A film having a three layer structure was prepared  
5 by applying a thermoplastic resin (polyamide 12  
microns at 175°C) having a melting point equal to or  
lower than 200 degrees Celsius onto the surface of a  
polyimide film (made by Ube Kosan Co., Ltd., SGA, 50  
microns thick) as adhesive layers (30 microns thick).

10 The film having the three layer structure was used  
to prepare a semiconductor device using the same  
method as the embodiment 1, and the reflow  
characteristics and connection reliability of the lead  
and the solder bump of the obtained semiconductor  
15 device were checked by the same method as embodiment 1.

[0077]

(COMPARATIVE EXAMPLE 3)

A film having a three layer was prepared by  
applying an epoxy resin (made by Hitachi Chemicals Co.,  
20 Ltd., R021C) having a high modulus of elasticity at  
room temperature onto both surfaces of a polyimide  
film (made by Ube Kosan Co., Ltd., SGA) as adhesive  
layers (20 microns thick). This film was used to  
prepare a semiconductor device by the same method as  
25 the embodiment 1, and the reflow characteristics and

connection reliability of the lead and the solder bump of the obtained semiconductor device were checked by the same method as the embodiment 1.

[0078]

5 TABLE 1

10

15

	Elastic modulus (MPa)		Reflow test	Thermal cycling test (1,000 cycles)	
	Entire film 25°C	Adhesive layer (average at 200 to 250 °C)		Lead open failure (%)	Bump open failure (%)
Embodiment 1	788	4.3	No void	0	0
Embodiment 2	5000	1.5	No void	0	0
Embodiment 3	930	3.6	No void	0	0
Embodiment 4	4190	3.6	No void	0	0
Embodiment 5	3750	13	No void	0	0
Embodiment 6	3500	100	No void	0	0
Embodiment 7	3500	2000. 15	No void	0	0
Embodiment 8	10	2.5	No void	0	0
Embodiment 9	2000	100	No void	0	0
Embodiment 10	20	2.5	No void	0	0
Embodiment 11	30	3.5	No void	0	0
Embodiment 12	850	8.5	No void	0	0
Embodiment 13	3300	2000. 8.5	No void	0	0
Comparative example 1*	10	2.5	No void	10	0
Comparative example 2	1400	To 0	Void	5	0
Comparative example 3	11000	1100	No void	80	100

Flatness of the elastomer: Difference of height in Comparative Example was 50 micron (for a thickness of 150 microns) and 5 microns or less for all other samples.

20

25

[0079]



[EFFECTS OF THE INVENTION]

The present invention provides a semiconductor device having a excellent anti-reflow property characterized in that a tape material having a circuit layer and a semiconductor device are electrically  
5 connected; an external circuit for electric connection with a mounting substrate is provided on the aforementioned circuit tape; and a film material is used for adhesion between the aforementioned circuit  
10 tape and semiconductor element in such a way that they are insulated from each other; wherein this semiconductor device is further characterized in that the modulus of elasticity in the temperature range (200 to 250 degrees Celsius) under the reflow  
15 conditions for this film material for adhesion is not less than 1 MPa. The present invention also provides a manufacturing method characterized by excellent mass productivity when a film material is used on the portion buffering thermal stress resulting from  
20 thermal difference between the aforementioned semiconductor element and mounting substrate.

[0080]

The present invention also provides a manufacturing method characterized by excellent  
25 workability wherein the film material is superior in

flatness, and the difference of height is kept at 5  
microns or less for a thickness of 150 microns. The  
stress buffering effect of the film material ensures a  
high degree of connection reliability of both the lead  
5 portion for electrical connection with the circuit  
tape and semiconductor element and the bump for  
electrical connection between the semiconductor device  
and mounting surface in a temperature cycling test.

[BRIEF DESCRIPTION OF TEE DRAWINGS]

10 FIG. 1 is a diagram representing temperature  
dependency of the modulus of elasticity of materials;

FIG. 2 is a schematic illustration representing  
three manufacturing processes of the semiconductor  
device of the present invention, wherein

15 (2-a) shows the manufacturing method where the  
film is adhered previously to the circuit tape, (2-b)  
shows the manufacturing method where the film is  
adhered previously to the semiconductor, and (2-c)  
indicates the method where the circuit tape and  
20 semiconductor element are adhered together  
simultaneously via the film;

FIG. 3 is a schematic diagram indicating the  
continuous process for adhering the film using a long  
reel;

25 FIG. 4 is a schematic diagram showing a circuit

tape having a film with an adhesive agent layer;

FIG. 5 is a schematic diagram of a semiconductor element having peripheral pads;

FIGS. 6 are schematic cross sections showing  
5 examples of the semiconductor device having peripheral pads;

FIG. 7 is a schematic diagram showing a semiconductor element having pads located at the center; and

10 FIG. 8 is a schematic cross section showing an example of a semiconductor device using a semiconductor element having pads located at the center of the element.

[Legend]

- 15 2.1, 4.1, 6.1, 8.1 ... Circuit tape  
2.1.1 ... Lead connected to lead  
2.2, 4.2, 6.2, 8.2 ... Buffer film  
2.3, 5.1, 6.3, 7.1, 8.3 ... Semiconductor element  
2.4, 6.4, 8.4 ... Encapsulant  
20 2.5, 6.5, 8.5 ... External terminal (solder bump)  
3.1 ... Long reel of circuit tape  
3.2 ... Long reel of film  
3.3 ... Stamping jig  
3.4 ... Film formed on circuit tape  
25 4.1.1 ... Lead formed on circuit tape

4.3 ..... Adhesive layer

5.1.1, 7.1.1 ... Connecting pad

6.6 ... Outer frame (heat spreader, etc.)